

Welding and Fabrication Defects

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Introduction

Welding and fabrication defects can greatly affect the performance and longevity of steel structures. Having an understanding of the various defects, their causes and remedies can help to ensure higher-quality and longer lasting structures.

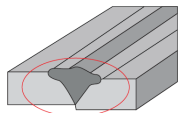
Upon detection of welding and fabrication defects, an evaluation should be carried out to determine their severity, and appropriate action taken. Even the most inconspicuous defect, can render a welded structure unfit to carry out its intended purpose. Distortion is a problem which can occur in welded structures because of the concentrated nature of the heat source.

This article details some of the more common defects, their causes and possible preventative and corrective measures.

1. Geometric Imperfections

Geometric imperfections refer to certain weld characteristics such as fit-up and weld bead shape as determined by visual inspection. They are an indication of poor workmanship and may be cause for concern if they exceed the acceptable limits of the quality control code being used for the weld inspection.

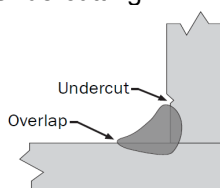
- Misalignment



This type of geometric defect is generally caused by a setup/fit up problem, or trying to join plates of different thickness.

- Overlap
The protrusion of weld metal beyond the weld toe or weld root. It is caused by poor welding techniques and can generally be overcome by an improved weld procedure. The overlap can be repaired by grinding off excess weld metal and surface grinding smoothly to the base metal.

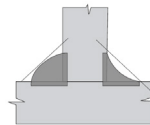
- Undercutting



Undercutting is one of the more severe welding defects. It is essentially an unfilled groove along the edge of the weld. The causes are usually associated with incorrect electrode angles,

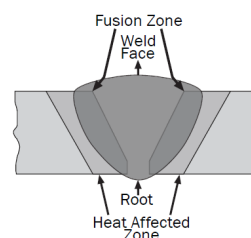
incorrect weaving technique, excessive current and travel speed. Undercutting can be avoided with careful attention to detail during preparation of the weld and by improving the welding process. It can be repaired in most cases by welding up the resultant groove with a smaller electrode.

- Concave and Convex Welds Misshaped welds



are caused by a combination of incorrect electrode current and speed. Excessive concavity (lack of reinforcement), results in insufficient throat thickness in relation to the nominated weld size. Excessive convexity results in poor weld contour. In multilayer welds this can give rise to slag inclusions, while in the finished weld it provides a poor stress pattern and a local notch effect at the toe of the weld. They can be avoided by using an appropriate electrode size, current and weaving pattern. Repair by either filling with further weld material or by grinding back to the base metal on each side of the weld and re-welding.

2. Cracking



Cracks and planar discontinuities are some of the most dangerous, especially if they are subject to fatigue loading conditions. There are several different types of cracks and none are desired. They



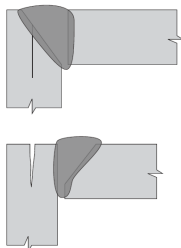
must be removed by grinding back (if superficial) or repaired by welding. Cracks can occur in the weld itself, the base metal, or the heat affected zone (HAZ).

Longitudinal cracks run along the direction of the weld and are usually caused by a weld metal hardness problem. This type of cracking is commonly caused by a cooling problem, the elements in the weld cooling at different rates. They can also be caused by; the weld bead being too wide, current or welding speed too high or having the root gap too large and also by shrinkage stresses in high constraint areas. Longitudinal cracks can be prevented by welding toward areas of less constraint, preheating the elements to even out the cooling rates and by using the correct choice of welding consumables. If cracks do appear they can be repaired by grinding out or cutting the members apart and re-welding.

A transverse crack is a crack in the base metal beginning at the toe of the weld. They are caused by transverse shrinkage stresses, and often indicates a brittleness problem in the heat affected zone. To prevent them it may require an increase in pre-heating or the use of a more ductile filler material. Underbead cracks are cracks in the unmelted parent metal of the heat affected zone and can be caused by hydrogen embrittlement (a process by which various metals become brittle and crack following exposure to hydrogen). To prevent these cracks use hydrogen controlled electrodes or preheat the elements being welded. These cracks can be repaired by gouging out and re-welding, but can only be found using non-destructive testing (NDT).

Cold cracking occurs after the weld metal has had the chance to completely solidify. They are caused by highly restrained welds, shrinkage and discontinuities. Cold cracks can be prevented by preheating the weldments, welding towards areas of less constraint as well as using more ductile weld metal. They can be repaired by removing and re-welding the elements together.

- Lamellar Tearing



Lamellar tearing is a type of defect that is most likely to occur below a welded joint at points of high stress concentration. It is created by non-metallic inclusions being rolled into the hot plate metal during fabrication. These tears occur when weld metal is deposited on the surface of a joint where there is high restraint. Special joint design is one way to minimize this defect but the best precaution is to specify materials of adequate quality and test at the receiving inspection.

3. Inclusions

Inclusions are generated by extraneous material such as slag, tungsten, sulfide and oxide inclusions becoming part of the weld.

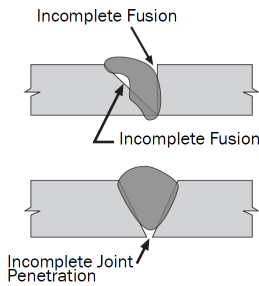
These defects are often associated with undercut, incomplete penetration and lack of fusion in welds. Insufficient cleaning between multi-pass welds and incorrect current and electrode manipulation can leave slag and unfused sections along the weld joint. Slag inclusions not only reduce cross sectional area strength of the joint but may serve as an initiation point for serious cracking. This defect can only be repaired by grinding down or gouging out and re-welding.

4. Porosity

Porosity is a collective name describing cavities or pores caused by gas and non-metallic material entrapment in molten metal during solidification. There are many causes which include contamination, inadequate shielding, unstable arc, arc gap too short and poor welding technique in general. Porosity can be minimized in many different ways - by the proper selection of electrodes and/or filler materials, improved welding techniques, more attention to the work area during weld preparation and a slower speed to allow gasses time to escape. The effects of porosity on performance depend on quantity, size, alignment, and orientation to stresses. When clustered at the weld's centre, porosity is not considered a dangerous fatigue promoter, or detrimental to fatigue resistance, although it may reduce the static stress carrying capacity of the weld.



5. Incomplete Fusion/Penetration



Incomplete fusion or penetration is an internal planar discontinuity that is difficult to detect and evaluate, and very dangerous. It occurs when the weld metal does not form a cohesive bond with the base metal or when the weld metal does not extend into the base metal to the required depth, resulting in insufficient throat thickness. These defects are usually caused by incorrect welding condition such as current too low, insufficient preheating, welding speed too fast, incorrect edge preparation, short arc length, insufficient electrode size or the arc was not in the centre of the seam. This type of defect can only be repaired by grinding/gouging out the defective area and re-welding.

6. Weld Damage

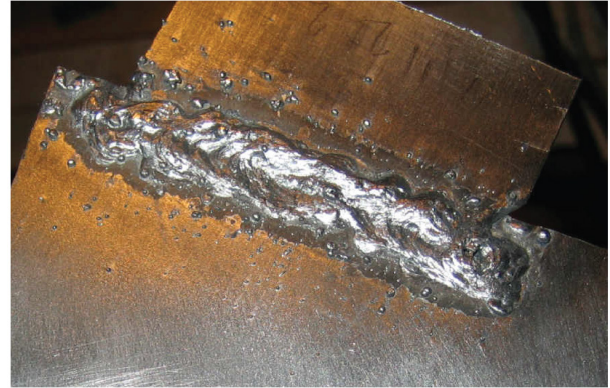
- **Hammer Marks & Arc Strikes** Arc strikes appear as localized spots of remelted metal. Hammer strikes are small dints or nicks. They are caused by excessive force when using a chipping hammer, careless handling of the welding electrode holder and from inadvertent or careless arc manipulation. They must be avoided, and any traces removed. These imperfections can lead to small cracks in the heat-affected zone of the weld metal and can cause localised stress concentrations.

7. Craters

Craters are visually inspectable depressions that indicate improper weld terminations, usually with the presence of radial cracks. They should be avoided if possible, the best way to do this is to ensure that correct welding techniques are used.

8. Spatter

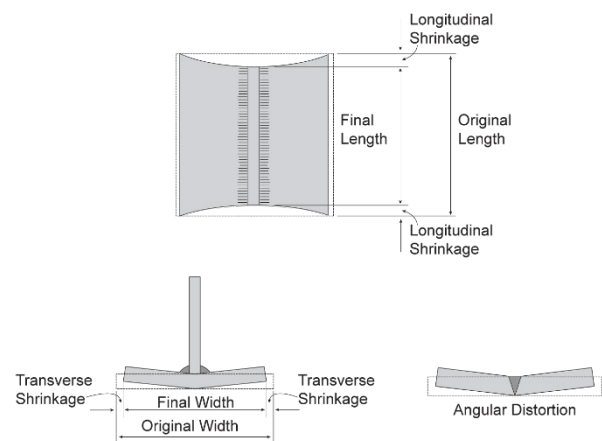
Metal drops expelled from the weld that stick to surrounding surfaces. Spatter can be minimized by correcting the welding conditions and should be eliminated by grinding when present.



Welding defects can greatly affect weld performance and longevity, early detection and correction is important to ensure that welds can carry out their designed purpose.

Detection techniques need to be sensitive enough to detect harmful or rejectable discontinuities but not to the point where all defects are rejected. It is only necessary to repair defects that are considered to be detrimental to the structural integrity of the structure. Welds don't have to be perfect, this is too costly and time consuming to achieve - simply within the acceptable working limits as specified by the quality control code being used during the weld inspection.

9. Distortion



Common types of distortion include shrinkage, angular distortion and bowing. Causes of distortion include the heat input, the degree of restraint applied and inherent stresses in the parent metal.



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